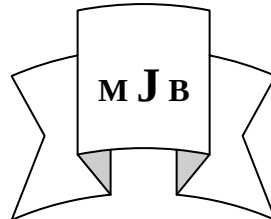


## The Clinical application of Tooth Size Analysis among Different Malocclusion Groups (A Cross Sectional, Comparative, Cephalometric Study)

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### **Abstract**

**Objective:** The aim of the investigation was to compare overall and anterior Bolton ratios in different malocclusion groups of sample of Iraqi patients applying for orthodontic treatment and to compare them with Bolton's standards.

**Setting:** cross-sectional, comparative, cephalometric study.

**Methods:** Cross sectional data was gathered from the study casts of patients need orthodontic treatment, after obtaining informed written consent from them. 130 out of 150 study casts were filtered based upon the inclusion and exclusion criteria. ANB angle was traced on corresponding lateral cephalograms. The mesio distal widths of all maxillary and mandibular teeth from right first molar to left first molar were calibrated with the use of a manual caliper. There were 55 class I, 38 class II division 1, 21 class II division 2 and 21 class III. The overall and anterior Bolton ratios for malocclusion group were compared with Bolton standard using students t-test

**Results:** Significantly higher mean anterior tooth ratios were found for skeletal CL II1 ( $p < 0.01$ ) patients. All other ratios were within close range of Bolton's norms.

**Conclusions:** Skeletal Class II patients showed a tendency towards higher mesio- distal widths of teeth in the maxillary anterior region.

### التطبيق السريري لتحليل حجم السن في مجاميع مختلفة في تشوه الاطباق (دراسة مقطعية مقارنة بالاشعة القياسية الجانبية)

#### الخلاصة

الهدف من الدراسة هو لمقارنة نسبة بولتن الكلية والامامية في مجاميع مختلفة في تشوه الاطباق مع نسبة بولتن القياسية وهي دراسة مقطعية مقارنة بالاشعة القياسية الجانبية.

تم جمع عينات مقطعية من الاوليات المأخوذة من القوالب الدراسية لعينة من المرضى المحتاجين للمعالجة التقويمية للاسنان بعد اخذ معلومات مكتوبة من المرضى. تم فلتر ١٣٠ قالب دراسي من اصل ١٥٠ اعتمادا على ضوابط الدراسة. تم قياس زاوية ANB من الاشعة القياسية الجانبية الخاصة بكل مريض وتم حساب عرض الاسنان العلوية والسفلية من اليمين الى اليسار باستخدام المسطرة اليدوية. وكان هناك ٥٥ مريض من الصنف الاول و ٣٨ مريض من الصنف الثاني فئة ١ و ٢١ مريض من الصنف الثاني فئة ٢ و ٢١ مريض من الصنف الثالث. تم مقارنة نسبة بولتن الكلية والامامية لمختلف المجاميع مع نسبة بولتن القياسية باستخدام student's t-test وكانت النتائج كالآتي :

وجود فرق احصائي مهم واكبر في نسبة بولتن الامامية لمرضى الصنف الثاني فئة ١ مقارنة مع نسبة بولتن القياسية. اما بالنسبة لباقي المجاميع فان النسب كانت مقاربة بالمقارنة مع نسبة بولتن القياسية.

### **Introduction**

A co-ordinated proportion between the mesio-distal dimensions of the upper and

lower teeth is necessary for good intercuspation. The presence of a tooth size discrepancy prevents the achievement of an ideal occlusion. In

the posterior region, a high percentage of finishing phase difficulties arise because of tooth size imbalance that could have been detected and considered during initial diagnosis and treatment planning. In some situations, tooth size discrepancy is not observed at the initial examination and could result in poor contacts, spacing, crowding, and an abnormal overjet and overbite [1]. Andrews [2] studied the dental casts of 120 non orthodontic individuals with normal occlusion and concluded that there are six essential 'keys' required to achieve this normal occlusion. McLaughlin et al. [3] stated that tooth size should be considered the 'seventh key' and that without coordination between the sizes of the upper and lower teeth, it would not be possible to obtain a good occlusion during the final stages of orthodontic treatment. This lack of co-ordination is called 'tooth size discrepancies' (TSD). Proffit et al [4] defined TSD as a disproportion among the size of individual teeth. Without a correct match of the mesiodistal widths of the maxillary and mandibular teeth, it is difficult to obtain an ideal overjet and overbite and a good occlusion during the final stages of orthodontic treatment. Bolton's analysis is one of the most popular methods for determining tooth size abnormality. It is useful in aiding diagnosis as well as in treatment planning. The overall Bolton ratio is the percentage obtained by summing the widths of the 12 mandibular teeth divided by the sum of the widths of the 12 maxillary teeth and should be  $91.3 \pm 0.26$  per cent. Anterior ratio is the percentage obtained by summing the widths of the six mandibular anterior teeth divided by the sum of the widths of the six maxillary anterior teeth and should be  $77.2 \pm 0.22$  per cent Bolton [5,6]. Most research on TSD investigated the effect of sexual dimorphism. They did

not, however, demonstrate a common trend, with most of the studies finding no differences in the prevalence of TSD between males and females [7-13]. On the other hand, Lavelle [14] and Smith et al [15] found significant differences in tooth size ratios for both genders. In a recent review Othman and Harradine [16] studies investigating TSD, no differences were found in the mean Bolton ratios between genders. In a few studies, however, the mean Bolton ratios for males were larger but the difference was small Othman and Harradine [16].

The aim of the present investigation was to calculate the overall and anterior Bolton ratios in different malocclusion groups of sample of Iraqi patients applying for orthodontic treatment and to compare them with Bolton's standards.

### **Material and Methods**

The study material comprised 135 pre-treatment study casts, selected from models of 150 patients, who during 2010–2011 applied to the university department of orthodontics and two private orthodontic practices for orthodontic treatment. Each of the patients had a cephalometric radiograph. The diagnosis of a Class I occlusion was based on a Class I molar and canine relationship as well as an ANB angle between 0 and 4 degrees. The diagnosis of a Class II was based on the presence of Class II molar and canine relationship accompanied by an ANB angle greater than 4 degrees. Overjet was a criterion to differentiate between Class II division 1 and 2. Class III was diagnosed based on an inverse overjet, a Class III molar and canine relationship as well as an ANB angle less than 0 degrees.

### **The inclusion criteria were:**

1. between 12 and 25 years of age

2. fully erupted permanent dentition from the first molar to the first molar in both arches
3. diagnostic records, including study casts, panoramic view, and a lateral cephalogram
4. the clinical diagnosis of Class I, II, or III malocclusion exemplified by the presence of its features regarding molar and canine relationship and overjet, as well as cephalometric analysis
5. absence of interproximal caries or restorations as well as prosthetic crowns or bridges

The study group included 55 Class I patients (30 males and 25 females), 38 Class II division 1 patients (20 males and 18 females), 21 Class II division 2 patients (9 males and 12 females), and 21 Class III (12 males and 9 females). All were of Iraqi nationality. The age distribution of the groups is shown in Table 1.

All measurements on the study models were undertaken by one author with sliding callipers (Dentaurum,

Pforzheim, Germany), accurate to the nearest 0.1 mm. The following were calculated for each pair of study casts.

S12mand—sum of the widths of the 12 mandibular teeth (mm)

S12max—sum of the widths of the 12 maxillary teeth (mm)

S6mand—sum of the widths of the 6 mandibular teeth (mm)

S6max—sum of the widths of the 6 maxillary teeth (mm)

Overall and anterior Bolton ratios, *Bor* and *Bar*, were calculated according to the following equations:  $Bor = S12mand/S12max$  and  $Bar = S6mand/S6max$ , respectively. The overall and anterior ratios for a particular malocclusion group was compared with Bolton's standard using the Student's *t*-test.

#### The exclusion criteria:

1. Presence of any deciduous tooth/teeth
2. Presence of any morphologic dental anomaly *ex. mesiodens, taurodontism, etc.*
3. History of orthodontic treatment

**Table 1** Age distribution between the groups investigated

| <b>Malocclusion group</b>  | <b>Sample size</b> | <b>Range<br/>(year-month)</b> | <b>Mean<br/>(year-month)</b> |
|----------------------------|--------------------|-------------------------------|------------------------------|
| Class I male               | 30                 | 12.42–25.17                   | 14.43                        |
| Class I female             | 25                 | 12.53–25.08                   | 16.32                        |
| Class II division 1 male   | 20                 | 12.08–25.42                   | 14.25                        |
| Class II division 1 female | 18                 | 12.75–25.00                   | 14.33                        |
| Class II division 2 male   | 9                  | 12.25–25.17                   | 15.53                        |
| Class II division 2 female | 12                 | 12.00–25.97                   | 16.25                        |
| Class III male             | 12                 | 12.87–25.42                   | 15.33                        |
| Class III female           | 9                  | 12.50–25.58                   | 14.67                        |

## Results

The overall Bolton ratio for all the malocclusion groups is shown in Table 2. There was no statistically significant differences found for the whole study group as well as for the subgroups of subjects with Class I, II and class III malocclusions.

The results for anterior Bolton ratio in the individual malocclusion groups are

presented in Table 3. Comparing anterior ratio in the individual malocclusion groups with Bolton's standards, statistically significant differences were observed for the whole study groups and for both genders as well as for the subgroups of subjects with Class II malocclusions.

**Table 2** Overall Bolton ratio in the individual malocclusion groups

| <i>Malocclusion group</i>  | <i>Sample size</i> | <i>Minimum</i> | <i>Maximum</i> | <i>Mean</i> | <i>SD</i> | <i>Coefficient of variation (%)</i> | <i>P value</i> |
|----------------------------|--------------------|----------------|----------------|-------------|-----------|-------------------------------------|----------------|
| Class I male               | 30                 | 86.5           | 96.0           | 91.9        | 2.09      | 2.3                                 | NS             |
| Class I female             | 25                 | 86.0           | 95.9           | 91.2        | 2.22      | 2.4                                 | NS             |
| Class II division 1 male   | 20                 | 86.6           | 94.0           | 91.0        | 2.08      | 2.1                                 | NS             |
| Class II division 1 female | 18                 | 86.4           | 97.7           | 91.3        | 2.14      | 2.7                                 | NS             |
| Class II division 2 male   | 9                  | 83.7           | 95.0           | 91.1        | 2.22      | 2.2                                 | NS             |
| Class II division 2 female | 12                 | 84.9           | 95.1           | 91.2        | 2.25      | 2.5                                 | NS             |
| Class III male             | 12                 | 83.9           | 95.9           | 91.1        | 2.16      | 2.4                                 | NS             |
| Class III female           | 9                  | 84.7           | 96.1           | 91.7        | 2.21      | 2.4                                 | NS             |
| Total male                 | 71                 | 84.6           | 96.3           | 91.1        | 2.14      | 2.4                                 | NS             |
| Total female               | 64                 | 84.5           | 95.4           | 91.2        | 2.19      | 2.5                                 | NS             |
| Total                      | 135                | 83.9           | 95.9           | 91.1        | 2.16      | 2.4                                 | NS             |

NS, not significant. \*\* $P < 0.01$ , \*\*\* $P < 0.001$ .

**Table 3** Anterior Bolton ratio in the individual malocclusion groups

| <i>Malocclusion group</i>  | <i>Sample size</i> | <i>Minimum</i> | <i>Maximum</i> | <i>Mean</i> | <i>SD</i> | <i>Coefficient of variation (%)</i> | <i>P value</i> |
|----------------------------|--------------------|----------------|----------------|-------------|-----------|-------------------------------------|----------------|
| Class I male               | 30                 | 74.3           | 84.2           | 77.1        | 2.13      | 2.4                                 | NS             |
| Class I female             | 25                 | 73.4           | 83.7           | 77.2        | 2.19      | 2.5                                 | NS             |
| Class II division 1 male   | 20                 | 72.5           | 84.5           | 80.1        | 2.46      | 3.1                                 | ***            |
| Class II division 1 female | 18                 | 72.2           | 84.4           | 79.8        | 2.63      | 3.3                                 | ***            |
| Class II division 2 male   | 9                  | 71.5           | 83.8           | 78.4        | 2.71      | 3.5                                 | **             |
| Class II division 2 female | 12                 | 72.5           | 87.3           | 78.4        | 2.80      | 3.6                                 | ***            |
| Class III male             | 12                 | 70.6           | 86.3           | 77.3        | 2.24      | 2.7                                 | NS             |
| Class III female           | 9                  | 70.6           | 87.1           | 77.1        | 2.12      | 2.3                                 | NS             |
| Total male                 | 71                 | 71.5           | 89.2           | 78.9        | 2.70      | 3.4                                 | ***            |
| Total female               | 64                 | 68.5           | 88.5           | 78.6        | 2.83      | 3.6                                 | ***            |
| Total                      | 135                | 68.5           | 89.2           | 79.34       | 2.77      | 3.5                                 | ***            |

NS, not significant. \*\* $P < 0.01$ , \*\*\* $P < 0.001$ .

### **Discussion**

The importance of tooth size discrepancy in treatment planning has been the subject of various discussions in orthodontic literature. In our study, a comparison was made between tooth size discrepancy in skeletal Class I, II and III patients based on cephalometric findings. The mean total ratio for the whole sample was 91.10% which is very close to Bolton's proposed ideal ratio. However the anterior ratio for the whole sample was found to be 79.34%, which is much higher than Bolton's proposed ideal ratio, thus reflecting a tendency towards greater mesiodistal widths in the maxillary anterior segment in our sample. In skeletal Class I patients, the mean total ratios calculated were 91.9%, 91.2% respectively and the mean anterior ratios calculated were 77.1%, 77.2%

respectively both of which are close to Bolton's proposed ideal ratios. Similarly the total mean ratio calculated for skeletal Class II (91.0%, 91.3%, 91.1%, 91.2) and Class III (91.1%, 91.7%) patients and the anterior mean ratio for skeletal Class III patients (77.3%, 77.1%) was in close agreement with Bolton's proposed ideal ratios. A peculiarity was the finding of significantly higher ( $p < 0.01$ ) mean anterior ratio (80.1%, 79.8%, 78.4%, 78.4%) for skeletal class II patients. This reflects a tendency towards wider mesiodistal dimensions in the maxillary anterior segment in our population sample. Usually the opposite of this is assumed to be true. No correlation between angle's classification of malocclusion and Bolton discrepancy was shown by Crossby and Alexander in 1989[17].

Their study included 109 pretreatment models of orthodontic patients of Class I, Class II Div 1 and Class II Div 2 malocclusion. Nie and Lin in 1999[7] studied 60 cases of normal occlusion and 300 cases of various malocclusion groups for interarch tooth size discrepancy. They found no significant difference between various malocclusion subgroups. However, Class III cases showed the greatest discrepancy in both anterior and overall ratios, followed by Class I and then Class II. In 2001 Ta TA et al [18] studied Bolton's ratios in Southern Chinese children. Their sample included 50 Class I cases, 30 Class II cases and 30 Class III cases that were randomly selected from 1247 children. No significant gender difference was found. A significant difference (  $p < 0.05$  ) was found between Class III groups and Bolton's norms for anterior ratio. For overall ratio, a significant difference ( $p < 0.05$ ) was found between class II cases and Bolton norms and also between Class II and Class III cases ( $p < 0.05$ ). In 2002 Alkofide and Hashim [8] studied the intermaxillary tooth size discrepancy in Saudi population. The sample consisted of 240 subjects, 60 cases in each malocclusion group. A significant difference was observed only for anterior ratios in class III groups. Laino et al [1] found no relation between inter and intra arch tooth size discrepancy and malocclusion groups. Their sample comprised of 94 pre treatment models of orthodontic patients. Araujo and Souki in 2003[9] studied 300 subjects who were allocated to three malocclusion groups with each group containing 100 individuals. The classification was done on the basis of ANB angle and Sassouni analysis. Significantly higher anterior mean ratios were found in Class III groups as compared to Class I and Class II groups. Tooth size discrepancy was found to be more

prevalent in Class I and Class III groups. Afzal et al in 2005[19] studied Bolton's ratios in 3 malocclusion groups in 55 Pakistani patients. While Class III group had the largest ratio followed by Class II and then by Class I, their differences were not statistically significant. In 2005 Uysal et al [20] compared interarch tooth size discrepancy in 150 untreated, normal occlusion subjects and 560 patients of four different malocclusion groups. A gender dimorphism was found in the normal subjects. All malocclusion groups showed significantly higher overall ratios than normal occlusion groups ( $p < 0.001$ ). However no statistically significant difference was found between the malocclusion groups. Basaran et al in 2006 [21] failed to show any gender dimorphism or statistically significant difference of Bolton's tooth size discrepancy among different malocclusion groups. The sample was of 60 normal occlusion groups and 300 patients divided into various malocclusion groups on the basis of dental and skeletal pattern. The study was conducted in a Turkish population. Fattah et al in 2006 [22] assessed interarch tooth size discrepancy among different malocclusion groups. The study was conducted using pre treatment models of 200 patients with equal gender distribution and from four malocclusion groups. The models were selected from the records of the Orthodontic class II patients. This reflects a tendency towards wider mesiodistal dimensions in the mandibular anterior segment in our population sample. Usually the opposite of this is assumed to be true. There was a significant difference in the anterior tooth ratios between Class I and Class II patients. However, no significant difference between Class I and Class III or Class II and Class III patients was observed. No correlation between angle's classification of

malocclusion and Bolton discrepancy was shown by Crossby and Alexander in 1989 [17]. Their study included 109 pretreatment models of orthodontic patients of Class I, Class II Div 1 and Class II Div 2 malocclusion. Nie and Lin in 1999 [7] studied 60 cases of normal occlusion and 300 cases of various malocclusion groups for interarch tooth size discrepancy. They found no significant difference between various malocclusion subgroups. However, Class III cases showed the greatest discrepancy in both anterior and overall ratios, followed by Class I and then Class II. However, a significant difference was found in all malocclusion cases as compared to Bolton's norms. In 2005 Hamid and Babar [23] did not find any difference in Bolton's ratios between different malocclusion groups. His sample comprised of 55 orthodontic patients of different malocclusion groups. The models were selected from the records of the Orthodontic department, Shiraz Dental School, Iran. The mean overall ratios in order were Class III > Class I > Class II Div 2 > Class II Div 1. The mean anterior ratio for the Class III sample was significantly greater than that for Class II subjects but showed no significant difference from the Class I subjects. The posterior and overall ratio of the Class III malocclusion group was statistically significantly greater than the other malocclusion groups ( $p < 0.05$ ). Al Khateeb and Abu Alhaija [24] in 2006 found no statistically significant differences in Bolton's ratios between the different malocclusions. Their sample consisted of 140 orthodontic models of school children aged between 13–15 years of Jordanian origin. The results of this study are in partial agreement with some of the above studies in the fact that no significant difference was found between Bolton's norms and tooth size ratios in Class I patients.

However, unlike other studies, Class III patients did not show a significantly higher anterior tooth ratio as compared to Class I patients. The observation that Class II subjects showed a significantly higher anterior ratio, indicating a tendency towards wider mandibular teeth has not been reported before. Perhaps the reason for this is that all except one previous study 20 classified patients into different malocclusion groups based on study cast relations, whereas this study used corresponding cephalometric tracings to classify the patients into different groups.

### **Conclusions**

- Skeletal Class I and Class III patients showed mean interarch tooth size ratios within close range of Bolton's norms.
- Skeletal Class II patients showed significantly higher mean anterior tooth ratios as compared to Bolton's norms. The mean total tooth ratios were within close range of Bolton's norms.
- A larger study at the national level is required to verify the applicability of these results to our population.

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